UCL Université catholique de Louvain

LMAPR1491

2012-2013

Statistical & quantic physics

5.0 credits	30.0 h + 30.0 h	1q

Teacher(s) :	Rignanese Gian-Marco (coordinator) ; Charlier Jean-Christophe ; Gonze Xavier ; Piraux Luc ;
Language :	Français
Place of the course	Louvain-la-Neuve
Prerequisites :	FSAB 1203 Physics 3 or an equivalent course, with an introduction to quantum physics FSAB 1105 Probability and statistics or an equivalent course. FSAB 1106 Applied mathematics (the part about the Fourier transform) or an equivalent course.
Main themes :	The module is divided into 2 parts. In the first part, centred on quantum mechanics, one reviews basic notions, and completes the exposition of these (measure theory). Then, one examines the Hydrogen atom, the harmonic oscillator (Dirac's method), some basics of molecular physics. In the second part, centred on statistical physics, one presents basic notions, the kinetic theory of gases, the different statistical ensembles (microcanonical, canonical and grand-canonical), and quantum fluids (fermions and bosons)
Aims :	This module aims at completing the student formation in physics, in view of the understanding of the properties of atoms, molecules, solids and nanostructures. At the end of the formation, the student will be able to use quantum mechanics to understand the electronic structure and the cohesion of such systems, as well as to use statistical physics to forecast their energetical behaviour as a function of temperature . *The contribution of this Teaching Unit to the development and command of the skills and learning outcomes of the programme(s) can be accessed at the end of this sheet, in the section entitled “Programmes/courses offering this Teaching Unit”.*
Teaching methods :	Ex-cathedra lectures and exercises.
Content :	Part 1 : Quantum physics 1.1. Introduction and reviews 1.2. Postulates 1.3. Hermitian operators 1.4. Measure theory (including Heisenberg uncertainty principle) 1.5. Hydrogen atom 1.6. Polyelectronic atoms 1.7. Matrix mechanics 1.8. Harmonic oscillator (creation and annihilation operators) 1.9. Spin 1.10. Variational principle 1.11. Tight-binding method (understanding of the electronic structure and cohesion of diatomic molecules) Part 2 : Statistical Physics 2.1. Introduction: Elements of Statistical Physics 2.1.1 Fundamentals of Statistical Physics 2.1.2 Phase space and representative points 2.1.3 Equiprobability principle 2.1.4 Mean value of an observable 2.1.5 Notion of ensemble 2.2. Kinetic Theory of Gases 2.2.1 Definition of an ideal gas 2.2.2 Model and properties of an ideal gas 2.2.3 Energy equipartition theorem 2.2.4 Speed distribution function 2.2.5 Maxwell-Boltzmann statistics 2.3. Microcanonical Ensemble 2.3.1 Microcanonical formalism : the entropy representation 2.3.2 Einstein model for the lattice specific heat 2.3.3 Model for a system with two energy states 2.3.4 Counting techniques and high dimensionality 2.4. Canonical Ensemble 2.4.1 Canonical formalism : the Helmholtz representation

	2.4.2 Notion of partition function 2.4.3 Notion of density of states 2.4.4 Debye model for the lattice specific heat 2.4.5 Black body model (Stefan-Boltzmann law) 2.5. Grand-Canonical Ensemble 2.5.1 Grand-Canonical formalism 2.5.2 Indistinguishability principle 2.5.3 Model of molecular adsorption at the surface of a material 2.5.4 Model of the fermion pre-gas 2.6 Quantum Fluids 2.6.1 Notions of Fermions and Bosons 2.6.2 The ideal Fermi fluid 2.6.3 Fermi-Dirac statistics 2.6.4 Properties of a fermion gas (electronic specific heat) 2.6.5 The ideal Bose fluid 2.6.6 Bose-Einstein statistics 2.6.7 Notion of Bose-Einstein condensation 2.6.8 Properties of a boson gas (superfluidity and superconductivity)
Cycle and year of study :	> Bachelor in Engineering > Bachelor in Engineering > Master [120] in Biomedical Engineering
Faculty or entity in charge:	FYKI